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Cancer risks in the Druze Isifya Village: Reasons and RF/MW antennas☆

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Abstract

Background: The present study was initiated to examine the claims of the residents of the Druze Isifya Village in Northern Israel that their high cancer rates were associated with the past exposures to radiation from radio and cellular transmitters. **Objective:** To investigate the association between past exposure to RF/MW transmitters and cancer risks, taking into account familial cancer history, occupational exposures and indicators of life-style. **Methods:** We carried out a population-based case-control study involving 307 residents, of whom 47 were diagnosed between 1989 and 2007 with different types of cancer and 260 controls. Cancer diagnoses were obtained from medical the records. Exposure status of individual houses were determined from a map, based on the distances between each house and RF/MW antennas, and were calculated using geographic information systems (GIS) tools. Data on additional risk factors for cancer, like smoking and occupation, were obtained from individual questionnaires. The analysis was adjusted for measures of life style and occupational exposure, and Binary multiple logistic regressions was used, for all cancer sites and for individual cancer types for those cancers with at least 5 documented cases. **Results:** Past occupational exposures to chemicals (e.g., pesticides) and electronics, were found to be strongly associated with increased cancer risks (all sites: OR = 2.79; CI = 1.14–6.82; $P < 0.05$), but no discernible trend in overall cancer risk was associated with proximity to sources of past RF/MW radiation exposure ($n = 47$ OR = 1.00; CI = 0.99–1.02; $P > 0.4$). Colorectal cancer showed a negligible elevated adjusted risk associated with radiation intensity ($n = 11$ OR = 1.03; CI = 1.01–1.05; $P < 0.01$). **Conclusion:** There was evidence for an increased risk of cancers which were associated with chemicals in manufacturing and agriculture and electronics, where there may have been exposures to EMF, but the study did not confirm the suspicion of increased cancer risks associated with radiation for most cancer types in this village. Misclassification of past exposures could explain the negative finding.
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Keywords: Cancer; Agrochemicals; Electronics; Microwave radiation; RF/MW transmitters; Retrospective study

1. Introduction

The general public has become increasingly exposed to radio and microwave radiation at frequencies of 100 kHz–300 GHz from radio and cellular transmitters, wireless computers (Wi-Fi technology), wireless telephones with base stations in the house (the DECT technology), personal digital assistance (PDA) devices and cellular phones. There is uncertainty, however, as to whether these exposures pose risks for cancer and other health effects. Several studies have been published to date describing the relationship between RF/MW radiation exposure from base stations and different health symptoms, such as sleep disturbances, heart rhythm disruption, headaches, dizziness and depression (see *inter alia* [1–4]).

However, epidemiological evidence on community RF/MW radiation and cancer accumulated to date is based mainly on associations, and assessments of group exposures, without information on individual exposures, and therefore may be biased towards the null by exposure misclassification. Several studies indicated an increased risk for cancer associated with living in vicinity of transmitters, but these studies had less than complete information on exposure assessment and possible confounders [5–10].

☆ I, as Editor in Chief, present my apologies to the authors as this paper appears only in 2011 although it was accepted already in 2010. We have tried to clarify the reason and will smooth the workflow in the future.

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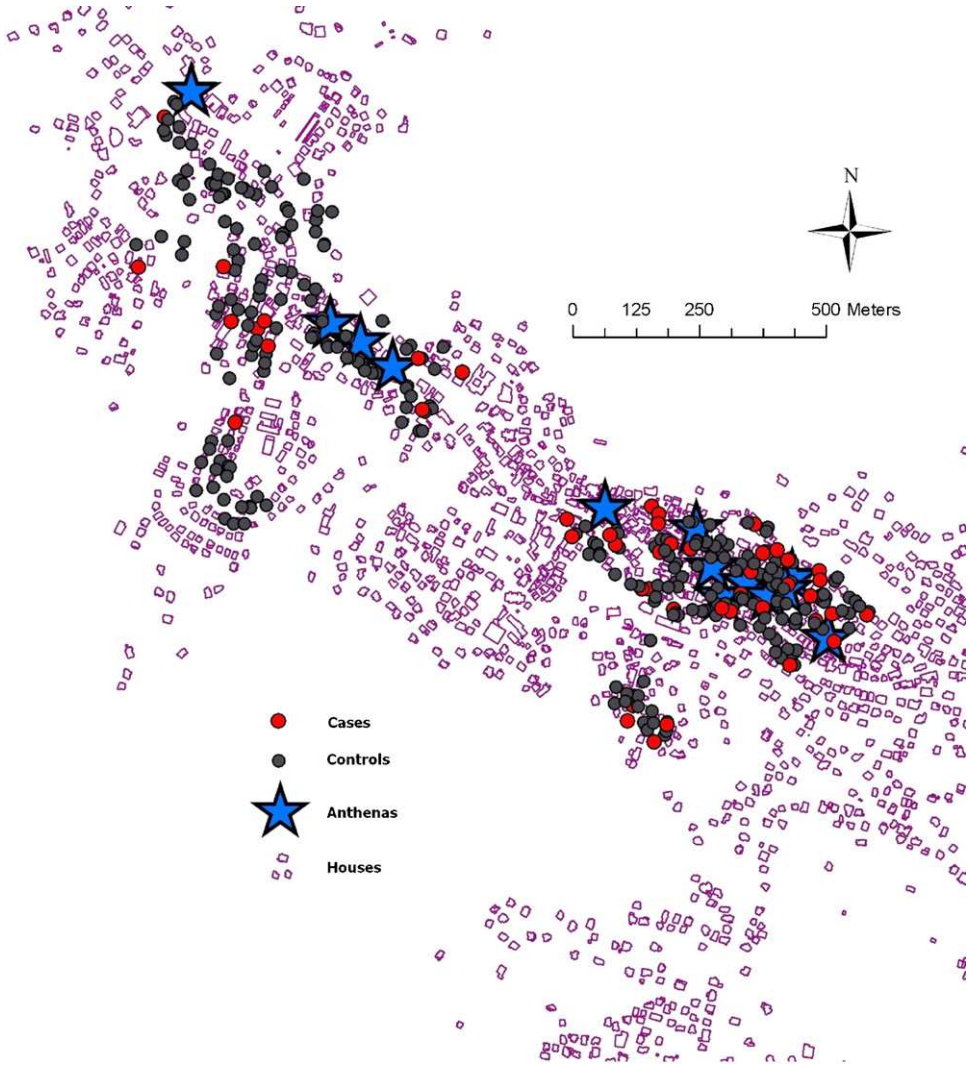

Fig. 1. The map of the Isifya village with houses, research subjects in neighbourhoods A, B, C, and RF/MW transmitters.

Isifya Village is located on the top of the Carmel Mountain (about 750 m above the sea level). Its hilltop location made it especially attractive for communication companies to erect their towers and antennas as they can so cover wide distances with their services. The first radio transmitters in the village were erected in the beginning of the 1970s. Cellular antennas were added in the 1990s. In 2000, all the cellular antennas and radio transmitters in the village were destroyed by local residents who attributed different health symptoms to the radiation [11,12].

According to the National Cancer Registry [13], there was an excess of cancer morbidity in Isifya, during the years 1998–2001, especially in men (RR = 1.57; CI (95%) = 1.12–2.02). There were specific types of cancer for which it was possible to make individual calculations. For lymphoma, in men on the basis of 7 cases in this period, RR was 2.28; ($CI_{95\%}$: 0.59–3.97) and colorectal cancer rate in men, on the basis of 8 cases, the RR was 2.01 ($CI_{95\%}$ 0.62–3.4) *ibid*.

The aim of this study was to determine the possible reasons of cancers and if there were elevated cancer risks associated with living in proximity to non-ionizing radiation emitting transmitters. The study was carried out to address concerns of the local residents of the village about their exposure to radio and cellular transmitters.

2. Materials and methods

The present analysis is a retrospective follow up study. Because most houses in the village do not have street numbers, cancer registry data were unavailable for the study. Therefore, in the analysis, we relied on medical documents with confirmed diagnosis of cancer. Informed consent forms were signed by all the participants. The questionnaires were filled in face-to-face interviews by a single interviewer (IA) in the participant's home. The questionnaires included questions about cancer history in the family; education;

marriage in the family (e.g., with cousins, which is not uncommon among the Druze); familial polyposis (a precancerous lesion); occupational exposures; smoking and passive smoking; duration of residence in the same house; alcohol consumption; nutritional habits; frequency of physical exercise; the use of cellular phones; exposure to wireless equipment in the house (such as digitally enhanced cordless telephones-DECT); use of oral contraceptives or hormones replacement therapy (HRT) and income (below average, average and above average). For deceased cancer patients, a family member was asked to fill in the questionnaire. Each visited house was marked on the map of the village, and the same process was used for controls.

The houses were then mapped in the ArcGIS9™ software using the building layer (map) provided by the local municipality. The radio and cellular transmitters, located in the village prior to 2000, were also mapped in the ArcGIS9™ software as a separate layer (Fig. 1). Information on the transmitters' locations was confirmed by the municipality.

We discovered that several families in the village had antennas on their home's roofs. These antennas were also mapped. The GIS layers for mapping antennas and houses were then used to calculate distances between each house and the nearest antenna. The study has 85.42% statistical power of detecting an odds ratio of 2.6 for 0.05 statistical significance level (Open Epi, Appendix A).

The study was approved by the Helsinki Committee of the local "Rambam" hospital. Informed consent forms were signed by all the participants.

2.1. Eligibility

Cancer cases were defined as eligible for inclusion on the basis of official medical documents and histopathology diagnosis of cancer. Altogether, 348 residents of the village were surveyed with a questionnaire that included the diagnosis details vs. controls, of whom 47 had cancer: colorectal [11], breast cancer [10], lymphoma [6], leukemia [3], lungs [2], uterine [2], liver [2], stomach [2], ovarian [2], pancreas [2], prostate [2], cervix [1], brain [1], and bladder [1].

Excluded from analysis were residents who migrated to the area after the year 2000 and also patients without documents, which left us with 307 subjects, of whom 47 were diagnosed with cancer. There was only 1 cancer patient (male) among the 28 people who migrated to the area after 2000 (22 females and 6 males).

Houses built in the last 10–15 years were also excluded from the sample, to account for latency effects.

2.2. Exposure assessment

Individual exposure (E) was estimated using the following formula: $E = 1/D^2$, where D is distance (in meters) between a house and the closest transmitter, following studies reported observed intensity decreases in the inverse proportion to the squared distance from the radiation source (see *inter alia* [14]) remembering that the major transmitting power of the RF/MW antennas is, however, directed to the horizon while the cellular phone base stations are aimed at a proximal radius of downward sites.

2.3. Statistical analysis

For the statistical analysis of the questionnaire we used the binary logistic regression model in SPSS 15.0™, in which radiation intensity (see Section 2.2) was adjusted for individual variables associated with cancer risk: one of these variables, nutrition habits in the village were found to be quite uniform among the population with a high prevalence of meat eating, shifts from traditional foods and exposure to processed foods in recent years. Occupational exposure was classified into three groups: working in construction, with pesticides, electronics and industrial chemicals vs. occupations with no exposure to industrial or agriculture particular risk factors, and the unemployed.

3. Results

The general characteristics of the study population are reported in Table 1. 15.3% of the studied population was found to have cancer.

Location: Most of the cancer cases (68%) were found in the neighbourhood near the antennas, assumed to have

Table 1
Basic characteristics of the Isifya study population.

Parameter	No.	%
Age (for male and female)		
Mean	48	
Median	48	
Gender		
Male	118	38.4
Female	189	61.6
Marriage with cousins within the family		
No	252	82.1
Yes	55	17.9
Smoking		
No	264	86
Yes	43	14
Occupation		
Chemicals and electronics	43	14
Other	264	86
Education		
Elementary and high school	217	70.7
Higher education and no education	90	29.3
Exposure time (years)		
Mean	21.8	
Min	1	
Max	30	
Std. deviation	8.689	
Distribution of cancer cases by neighbourhood		
A: Old neighbourhood (more exposed)	32	68%
B: Less exposed neighbourhood	11	23%
C: Unknown exposure	4	8.5%

Table 2
Factors possibly affecting cancer risk (Method – logistic regression; cancer with at least 5 recorded cases).

Variable	All sites, OR (95% CI)	Colorectal, OR (95% CI)	Lymphoma, OR (95% CI)	Breast, OR (95% CI)
No of cases/controls	47/260	11/296	6/301	10/297
Personal/SES				
Age	1.03 (1.00–1.06)	1.04 (0.99–1.10)	0.98 (0.91–1.05)	1.11 (1.01–1.20)
Gender	0.88 (0.38–2.04)	0.15 (0.02–0.94)	0.00	0.00
Education	0.49 (0.21–1.11)	1.79 (0.44–7.22)	0.19 (0.01–2.28)	0.20 (0.01–3.29)
Marriage within family	1.00 (0.43–2.31)	0.38 (0.04–3.42)	4.68 (0.53–40.98)	2.83 (0.55–14.38)
Exposures				
Smoking	1.19 (0.44–3.20)	0.94 (0.16–5.46)	0.72 (0.10–4.91)	0.00 (0.00–)
Occupation	2.79 (1.14–6.82)	0.67 (0.12–3.78)	6.53 (0.95–44.62)	66.02 (2.20–1980.71)
Radiation intensity	1.00 (0.991–1.021)	1.03 (1.01–1.05)	0.95 (0.86–1.06)	0.84 (0.72–0.79)
Years of exposure to radiation	1.00 (0.95–1.05)	0.97 (0.877–1.082)	0.95 (0.82–1.11)	1.04 (0.89–1.20)
Familial risk				
Familial polyposis	–	4.0E+010 (0.00–)	–	–
Constant	0.00	0.13	14,977,946	0.00
R^2	0.12	0.27	0.33	0.40

Table 3
Results of logistic regression for less then 5 cases.

Variable	Leukemia, OR (95% CI)	Lung, OR (95% CI)	Uterine, OR (95% CI)	Ovarian, OR (95% CI)
No of cases/controls	3/304	2/305	2/305	2/305
Age	0.93 (0.83–1.05)	1.08 (0.92–1.26)	0.91 (0.79–1.06)	1.82 (0.59–5.62)
Gender	1,512,117.8 (0.000)	0.65 (0.000)	5,291,321.7 (0.00)	1.9E+017 (0.00)
Education	0.00 (0.000)	0.00	0.000 (0.00)	0.02 (0.00–4174.44)
Marriage within family	5.770 (0.32–101.45)	0.00 (0.00)	3.65 (0.21–62.40)	0.00 (0.00)
Smoking	17,426,730 (0.000)	61,840,428 (0.00)	0.63 (0.000)	50.36 (0.00)
Occupation	1.64 (0.08–33.79)	0.00 (0.00)	0.00 (0.00)	3.7E+010 (0.00–3.6E+030)
Radiation intensity	1.00 (0.94–1.06)	0.97 (0.80–1.18)	0.99 (0.91–1.07)	0.61 (0.22–1.69)
Years of exposure to radiation	1.06 (0.84–1.34)	0.94 (0.73–1.26)	1.12 (0.88–1.42)	0.36 (0.05–2.55)
Constant	0.00	0.00	0.00	0.00
R^2	0.30	0.55	0.23	0.71

the most intense exposures. This neighbourhood was also the most densely populated. The first diagram shows a clear reduction in the number of all cancer cases with increasing distance, possible relationship between distance to antenna transmitters and the increasing risk of cancer. The lower diagram also shows the second peak of cancer prevalence (within 300–350 m range), which may indicate points where radiation beam hits the ground depending on the transmission frequency. In fact, the pattern is consistent with sinusoidal model [15]. But since we had no specific characteristics of the antennas, we could not analyze these relationships further.

The results of the binary logistic regression analysis are reported in Table 2. Data on cancer types of less than 5 cases were analyzed and there were no notable findings (Tables 3–5). We summarize the noteworthy findings. As Table 2 shows, age was weakly associated with risk of colorectal cancer (OR = 1.04; $CI_{95\%}$ = 0.99–1.10; $P < 0.1$) and education was inversely associated with risks for cancer from all sites (OR = 0.49; $CI_{95\%}$ = 0.21–1.11; $P < 0.1$).

For all cancer sites, there was a statistically significant association between cancer and the occupational exposure to chemicals and electronics ($n = 43$; OR = 2.79;

Table 4
Results of logistic regression for less then 5 cases.

Variable	Cervix, OR (95% CI)	Bladder, OR (95% CI)	Prostate, OR (95% CI)	Liver, OR (95% CI)
No of cases/controls	1/306	1/306	2/305	2/305
Age	0.97 (0.70–1.35)	1.07 (0.79–1.46)	1.10 (0.89–1.37)	0.964 (0.82–1.13)
Gender	960,738.54 (0.00)	0.00 (0.00)	0.00 (0.00)	1.04 (0.02–51.87)
Education	12,094,055 (0.00)	10,761,740 (0.00)	0.00 (0.00)	0.00 (0.00)
Marriage within family	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Smoking	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Occupation	0.00 (0.00)	0.00 (0.00)	1.67 (0.04–61.04)	12.45 (0.34–453.54)
Radiation intensity	0.96 (0.78–1.99)	0.76 (0.33–1.78)	0.97 (0.86–1.10)	0.96 (0.84–1.11)
Years of exposure to radiation	0.88 (0.61–1.26)	16.419 (0.00–3.2E+184)	12.03 (0.00–5.6E+192)	7988.30 (0.00–7.2E+285)
Constant	0.00	0.00	0.00	0.00
R^2	0.42	0.62	0.54	0.40

Table 5
Results of logistic regression for less then 5 cases.

Variable	Pancreas, OR (95% CI)	Stomach, OR (95% CI)	Prostate, OR (95% CI)	Liver, OR (95% CI)
No of cases/controls	2/305	1/306	2/305	2/305
Age	1.02 (0.87–1.20)	1.09 (0.96–1.23)	1.10 (0.89–1.37)	0.964 (0.82–1.13)
Gender	0.00 (0.00)	9,569,283.1 (0.00)	0.00 (0.00)	1.04 (0.02–51.87)
Education	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Marriage within family	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Smoking	14.25 (0.03–5233.48)	0.93 (0.00)	0.00 (0.00)	0.00 (0.00)
Occupation	3.4E+0.008	0.00 (0.00)	1.67 (0.04–61.04)	12.45 (0.34–453.54)
Radiation intensity	1.11 (0.91–1.34)	0.99 (0.93–1.06)	0.97 (0.86–1.10)	0.96 (0.84–1.11)
Years of exposure to radiation	0.76 (0.48–1.18)	0.92 (0.79–1.08)	12.03 (0.00–5.6E+192)	7988.30 (0.00–7.2E+285)
Constant	0.00	0.00	0.00	0.00
R^2	0.59	0.25	0.54	0.40

Variable	Brain, OR (95% CI)
No. of cases/controls	1/306
Age	1.00 (0.84–1.20)
Gender	13,020,733 (0.00)
Education	0.00 (0.00)
Marriage within family	8.7E+009
Smoking	2.00 (0.00)
Occupation	5.07 (0.00)
Radiation intensity	1.06 (0.93–1.22)
Years of exposure to radiation	1.082 (0.66–1.76)
Constant	0.00
R^2	0.44

$CI_{95\%}$ = 1.14–6.82; $P < 0.05$). We had no data on the role of occupational non-ionizing radiation exposures in those reporting electronics exposures.

Estimated intensity of community radiation exposure was not associated with risk of all cancers ($n = 47$; OR = 1.00; $CI_{95\%}$ = 0.99–1.02; $P > 0.4$) and a minor association for colorectal cancer ($n = 11$; OR = 1.03; $CI_{95\%}$ = 1.01–1.05; $P < 0.05$). For breast cancer, there was an inverse association with estimated radiation intensity ($n = 10$; OR = 0.84; $CI_{95\%}$ = 0.72–0.79; P = 0.01). Other results of note were related to age at start of exposure, for all sites cancer, with older age, higher risk ($n = 47$; OR = 1.03; $CI_{95\%}$ = 1.00–1.06; $P < 0.05$), and for breast cancer ($n = 10$; OR = 1.11; $CI_{95\%}$ = 1.01–1.20; $P < 0.05$). There was a strong but non significant association between occupational exposures and lymphoma ($n = 4$; OR = 6.53; $CI_{95\%}$ = 0.956–44.622; $P < 0.1$).

The results were not changed for confidence intervals of 90% and 80%.

4. Discussion

Our study did not confirm the impression of an inverse association with proximity to estimated past locations of antennae (Fig. 2). The data did not also provide evidence for an increased risk of all cancers related to residents' estimated past exposure to non-ionizing radiation from radio neither the cellular transmitters in the Isifya Village. However, we found a low and inconsequential but significantly increased risk of colorectal cancer related to estimated past exposure

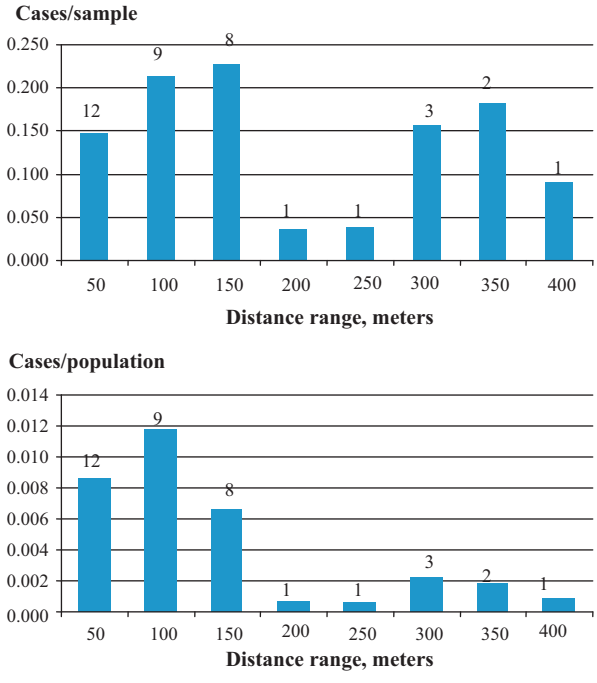

Fig. 2. Ratios between the total numbers of detected cancer cases in different distance bands from the RF/MW transmitters, estimated respectively for the total number of residents in each distance band (top diagram) and for the total number of people covered by the survey (bottom diagram). The labels above the columns represent the number of cancer cases for each range of distance.

to non-ionizing radiation. We did not find an association between colorectal cancer and familiar polyposis. We are aware of only one study on occupational exposure to RF/MW radiation that showed an increased risk for colorectal cancer [16]. Generally colorectal cancer is related to nutritional risk factors [17–21].

No increased risk was found for lymphoma and all sites cancer with relation to estimated past exposure to radiation. However a reduction of risk in relation to RF/MW was found for breast cancer. There is no indication for an inverse link between RF/MW and for breast cancer in the literature. The association of higher socioeconomic and the occurrence of breast cancer is well known. There is evidence in the literature of a correlation between higher incidence of breast cancer and high income populations [22,23].

We could not assess the role of lower socioeconomic status, but it cannot be ruled out as a possible explanation in the area closer to the antennas.

We found a high but non statistically significant association between occupational exposure to pesticides and industrial chemicals, including work with electronics and risk of lymphoma. The relationship between lymphoma and pesticides is consistent with findings from other studies [24,25] as well as the relationship with other cancers [26,27].

For all cancer sites, there was a statistically significant association between occupational exposure to chemicals and electronics. This finding is consistent with findings from experimental studies on an interaction between chemicals and microwave exposures: microwave fields interact at cell membranes with amplitude-modulated at ELF frequencies, and with chemical stimulations of chemical cancer promoters. [28]. Oxidative stress is increased from occupational exposures to EMF and chemicals [29]. Magnetic fields thus can act as a cancer promoter or work in synergy with other cancer promoters [30]. Microwave workers with more than 20 years of job experience, who were exposed to soldering fumes and/or electronic solvents, were found to have a 10-fold risk of brain tumors [31].

Experimental studies on RF and immunity, both epidemiological [32,33] and experimental studies [34–37] showed contradictory effects. For example, Cleary et al. [35] found both an increase and decrease of proliferation of T-lymphocytes, and Phillips et al. (1998) found both an increase and decrease of DNA damage.

Although smoking is a known, recognized significant factor in the development of many cancers [38–40], we did not find a statistically significant association between self reported smoking and cancer risk in this study, neither for individual cancers nor all sites.

Despite the impressions suggested by the mapping data, our logistic regression analysis did not discover an overall relationship between cancer and estimated past exposure to non-ionizing radiation.

Our study's strength is the inclusion of multiple risk factors such lifestyle, occupational exposures and genetic factors and the use of GIS, which enabled us to provide past individual exposure estimates and minimize exposure misclassification [41].

Our data analysis enabled us to exclude the possibilities that ethnic background, parity, age, birth rate, accounted for differences, as these factors were controlled for in the statistical analysis.

5. Study limitations

This study's major limitation is that we cannot exclude the possibility of exposure misclassification because of multiple sources (cellular and radio), influence of topographic factors, angle of beam in relation to residence of exposed subjects, and the lack of individual data on round the clock proximity to sources.

The lack of data on past actual radiation levels was a consequence of the fact that antennae were removed before the start of the study. Thus, there was the possibility of errors in reconstructing past exposures based on distance alone.

We recognize that distance is not a totally reliable proxy exposure indicator for RF-EMF exposure. Distance was found to be a good exposure proxy for a single AM transmitter and of limited informative value in studies involving several transmitters, especially when they operate in different frequency bands [42].

Another limitation is the small study population size and thus low statistical power. Our study was also limited by small number of cases from the types of cancer believed to associate with exposure – i.e., leukemia and lymphomas [7,10,43,44].

The study did not include the new metric, called GS units, measured with Graham/Stetzer meter, and reflecting average rate of change of high frequency voltage transients from electrical power wiring, that are caused by interruption of electrical current flow ("dirty electricity"). A recent study found that dirty electricity was related to increased cancer risk [45].

6. Conclusion

We observed an increased risk from occupational chemicals and electronics exposures, for breast cancer and all sites cancer, but no clear indication of increased risk of cancer (all sites) among residents of Isifya attributed to past estimated RF exposure to broadcasting towers.

Competing interests

The authors declare that they have no competing interests.

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Appendix A. Explanation of questionnaire variables

Age – at start of exposure.
Education level – no education, elementary school, high school, non academic above high school, and academic degree.
History of cancer – cancer in the family (first degree).
Marriage in the family – marriage to cousins or parents are cousins.
Occupation – housewives, unemployed, working at risk conditions (chemicals, radiation), and other – non risk exposure at work.
Smoking – never, used to smoke and stopped, smoking. Amount of cigarettes per day was not included in final analysis.
Passive smoking (exposure in house as a child).
Number of children (for number of pregnancies).
Familial polyposis – as a risk factor for colorectal cancer.
Nutrition
(A) Carnivore, vegetarian or vegan;
(B) Frequency of vegetables consumption;
(C) Frequency of industrial (processed) food consumption.
Alcohol – frequency and amount of consumption.
Time of exposure – years of exposure to transmitters.

Appendix B. Power calculation by Open Epi programme

Two-sided confidence interval (%) 95
Number of cases 47
Percent of exposure among cases (%) 68
Number of controls 260
Percent of exposure among controls (%) 44.6
Odds ratio 2.6

Power based on:

Normal approximation 85.42%
Normal approximation with continuity correction 81.1%

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